

# ANGULAR DISTRIBUTIONS IN HIGGS DECAYS

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A new theory yields unconventional results for the angular distribution of products like  $b - \bar{b}$  jets in Higgs decays.

According to a new fundamental theory,<sup>1,2</sup> Higgs fields have an unconventional equation of motion

$$-(g^{\mu\nu} D_\mu D_\nu + i\overline{m}e_\alpha^\mu \sigma^\alpha D_\mu) \Phi_h - \mu_h^2 \Phi_h + \bar{b} (\Phi_h^\dagger \Phi_h) \Phi_h = 0. \quad (1)$$

(See (13) of Ref. 2.) At very high energies and field strengths, this goes over to the usual form

$$\left[ -g^{\mu\nu} D_\mu D_\nu - \mu_h^2 + \bar{b} (\Phi_h^\dagger \Phi_h) \right] \Phi_h = 0. \quad (2)$$

At low energies and field strengths, however, it becomes

$$\left[ ie_\alpha^\mu \sigma^\alpha D_\mu + \tilde{\mu} - \tilde{b} (\Phi_h^\dagger \Phi_h) \right] \Phi_h = 0 \quad (3)$$

where  $\tilde{\mu} = \mu_h^2 / \overline{m}$  and  $\tilde{b} = \bar{b} / \overline{m}$ .

In flat spacetime ( $e_\alpha^\mu = \delta_\alpha^\mu$ ), and with gauge couplings ignored, (3) reduces to

$$i\sigma^k \partial_k \Phi_h = \left[ -i\partial_0 - \tilde{\mu} + \tilde{b} (\Phi_h^\dagger \Phi_h) \right] \Phi_h \quad (4)$$

for the original Higgs fields. For the physical Higgs boson  $\phi_h$ , on the other hand, a standard treatment gives the above equation of motion with  $-\tilde{\mu} \rightarrow \bar{\mu} = 2\tilde{\mu}$  and different self-interaction terms.<sup>3</sup> If these self-interactions are also neglected, we obtain

$$-\partial^k \partial_k \phi_h = (i\partial_0 - \bar{\mu})^2 \phi_h \quad (5)$$

so that

$$p^2 = (\omega - \bar{\mu})^2 \quad (6)$$

and

$$\omega = p + \bar{\mu} \quad (7)$$

for the physical branch, where  $p$  is the magnitude of the 3-momentum. Because the present picture involves (physically acceptable) violations of Lorentz invariance,<sup>1,2,4</sup> the energy-momentum relation of the Higgs is quite different from

$$\omega = \sqrt{p^2 + m_h^2} \quad (8)$$

and observable properties like angular distributions in decays are consequently predicted to be different.

A simple illustration is the kinematics of the  $h^0 \rightarrow q\bar{q}$  decay, with  $q$  representing a light particle like the bottom quark.<sup>5,6</sup> Conservation of energy implies that

$$p_h + m_h = p_q + p_{\bar{q}} \quad (9)$$

or

$$p_h^2 = p_q^2 + p_{\bar{q}}^2 + 2p_q p_{\bar{q}} + m_h^2 - 2m_h(p_q + p_{\bar{q}}) \quad (10)$$

if the mass of  $q$  is neglected. (We now write  $m_h$  for  $\bar{\mu}$ .) Conservation of 3-momentum gives

$$p_h^2 = p_q^2 + p_{\bar{q}}^2 + 2\mathbf{p}_q \cdot \mathbf{p}_{\bar{q}} \quad (11)$$

or, in terms of the opening angle  $\theta$ ,

$$p_h^2 = p_q^2 + p_{\bar{q}}^2 + 2p_q p_{\bar{q}} \cos \theta. \quad (12)$$

The predicted angular distribution

$$\cos \theta = 1 + \frac{m_h^2}{2p_q p_{\bar{q}}} - m_h \frac{p_q + p_{\bar{q}}}{p_q p_{\bar{q}}} \quad (13)$$

is then quite different from the standard result

$$\cos \theta = 1 - \frac{m_h^2}{2p_q p_{\bar{q}}} \quad (14)$$

for energies significantly above threshold. For example, if the emerging particles or jets have equal energy, and the total energy is twice the threshold for Higgs production, the opening angle is  $120^\circ$  in the present picture, rather than  $60^\circ$ .

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## References

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